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Proceedings of the Pacific regional peer review on Identification and Evaluation of Biological Effects and Impacts of Sediment to Sponge Communities in Hecate Strait

October 23-25, 2012
Nanaimo, British Columbia

Chairperson: Linda Nichol
Editor: Linda Nichol

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO), Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on October 23rd to 25th, 2012, at the Pacific Biological Station in Nanaimo, British Columbia. Two working paper were presented for peer review. One paper reviewed the physiological effects of remobilized sediment on glass sponges and the other used an ecological risk assessment framework approach to assess the level of exposure to remobilized sediment from historical fisheries activities.

In-person and web-based participation included DFO Science, Fisheries and Aquatic Management Sectors staff; and external participants the Province of British Columbia, the commercial fishing sector, environmental nongovernmental organizations, consultants, and academia.

The conclusions and advice resulting from this review will be provided in a Science Advisory Report to DFO Ecosystem Management Branch Pacific Region to provide an assessment of the nature and extent of the potential effects of sedimentation on glass sponge reefs and recommend mitigation measures for activities/areas where risks to these communities are identified.

The Science Advisory Report and supporting Research Document will be made publicly available on the CSAS Science Advisory Schedule at the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat (CSAS) Website.

Compte rendu de la réunion d'examen régional Pacifique par le Recensement et évaluation des effets biologiques et des conséquences des sédiments sur les récifs d'éponges du détroit d'Hecate

SOMMAIRE

Le présent compte rendu résume l'essentiel des discussions et des conclusions de la réunion régionale consultative du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada qui a eu lieu du 23 au 25 octobre 2012 à la station biologique du Pacifique de Nanaimo, en Colombie-Britannique. Deux documents de travail ont été soumis à l'examen par les pairs. L'un portait sur les effets physiologiques de la remobilisation des sédiments sur les récifs d'éponges siliceuses, l'autre appliquait l'approche du cadre d'évaluation du risque écotoxicologique pour évaluer le niveau d'exposition aux sédiments remobilisés à partir de l'historique des pêches.

Au nombre des participants qui ont assisté à la réunion en personne ou par conférence Web, il y avait notamment des employés des secteurs des Sciences et de la Gestion des pêches et de l'aquaculture de Pêches et Océans Canada, ainsi que des représentants de la province de la Colombie-Britannique, du secteur de la pêche commerciale, d'organisations non gouvernementales de l'environnement et du milieu universitaire, ainsi que des consultants.

Les conclusions et les avis qui ont découlé de cet examen feront l'objet d'un avis scientifique qui sera transmis à la Direction générale de la gestion des écosystèmes du Ministère de la Région du Pacifique, pour permettre d'évaluer la nature et la portée des effets possibles de la sédimentation sur les récifs d'éponges siliceuses et de recommander des mesures d'atténuation concernant les activités ou les zones qui posent des risques pour ces récifs.

L'avis scientifique et les deux documents de recherche à l'appui seront rendus publics sur le calendrier des avis scientifiques publiés sur le site Web du SCCS de Pêches et Océans Canada.

INTRODUCTION

A Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) was held October 23rd to 25th, 2012, at the Pacific Biological Station, Nanaimo, British Columbia, to review two working papers that addressed, in a complimentary manner, the nature and extent and effects of remobilized sediment on glass sponge reefs within the proposed Adaptive Management Zone (AMZ) of the Hecate Strait and Queen Charlotte Sound Sponge Reef proposed Marine Protected Area. The remobilization of sediment due to fishing has been a concern expressed in studies for decades, but remobilized sediments could have a variety of effects depending on the extent and duration of remobilization. The purpose of the CSAS review was to assess the physiological effects of remobilized sediment on sponges and then, with the use of ecological risk assessment frameworks, the extent and nature of the risks posed by remobilized sediment from historical fisheries to sponge reefs. The purpose was also to provide managers with an analysis of various options to mitigate these impacts and their potential for reducing the risks.

The Chair, Linda Nichol, welcomed participants and reviewed the role of CSAS in the provision of peer reviewed advice and gave a general overview of the CSAS process. The Chair discussed the role of participants, confidentiality requirements and the expected RPR document outputs (Science Advisory Report, Proceedings and Research Document) and their general purposes, as defined by CSAS. Everyone was invited to participate fully in the discussion and contribute knowledge to the process, with the goal of delivering a scientifically defensible product. It was confirmed with participants that all had received copies of the RPR Terms of Reference (Appendix 3) and the working paper. The Chair reviewed the agenda with the participants and two external reviewers. Lisa Spaven (DFO Pacific) was identified to the meeting participants as the rapporteur for the meeting.

The meeting participants were informed that Dr. Ellen Kenchington, DFO Maritimes Region, Bedford Institute of Oceanography, Dartmouth, Nova Scotia and Dr. Craig Young, Oregon Institute of Marine Biology, University of Oregon, had been asked prior to the meeting to provide detailed written reviews of the working paper to assist in shaping the review, but not limiting in any way, discussion by participants attending the peer-review meeting. The working paper authors were provided with copies of the reviews in advance of the meeting so that they were prepared to respond to the issues raised by the reviewers. Meeting participants were also provided with copies of the written reviews.

The Chair referred to the Terms of Reference (TOR) for the meeting (Appendix 3), and highlighted the objectives of this meeting which were to identify and evaluate the biological effects and impacts of sediment to sponge communities in Hecate Strait. In total, 33 people participated in the RPR (Appendix 2).

DETAILED COMMENTS FROM THE REVIEWS OF THE EFFECTS OF SEDIMENT ON GLASS SPONGE REEFS

WORKING PAPER 2:

Boutillier, J, Masson, D., Fain, I. Conway, K., Lintern, G, O, M, Davies, S., Mahaux, P., Olsen, N., Nguyen, H., Rutherford, K. 2012. The extent and nature of exposure to fishery induced remobilized sediment on the Hecate Strait and Queen Charlotte Sound glass sponge reef. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/074. vi + 23 p.

- Working paper accepted with revisions

- Reviewer Dr. Ellen Kenchington

The key questions or points posed by the reviewer are presented in italicized text. The responses of the authors are bulleted with an arrow.

GENERAL COMMENTS

The working paper presents a novel assessment of the dispersal trajectories of resuspended sediments created through fishing activities in the vicinity of the GSRs of Hecate Strait. The models are very interesting and help to contextualize the issue although the work cannot be viewed as a full PoE evaluation as it only deals with one stressor (change in sediment concentration) and then only deals with the area of impact caused by the stressor. This is not a criticism of this work as it is an essential first step and it is done very well. The authors also have done a good job of taking that information and putting it into a risk assessment framework and proposing some potential mitigation measures for consideration. The next steps should be to estimate sediment volumes resuspended by the fishing activities through modeling approaches which consider gear configurations and tow speeds to determine drag, the swept area and to evaluate natural sediment loads through the use of sediment traps in the impact areas. With this information the PoE can be fully assessed and residual effects of any mitigation methods can be evaluated.

SPECIFIC COMMENTS ON TERMS-OF-REFERENCE OBJECTIVES

Objective I: Completeness of the PoE evaluation

Pathways of Effects (PoE) as used by DFO have three linked elements: 1) a list of the activities that are involved; 2) the types of cause-effect relationships that are known to exist stemming from the activity; and 3) the mechanisms by which stressors produced by the activity ultimately lead to effects in the aquatic environment. The links between activities and effects are referred to as pathways and reflect points where mitigation measures may be applied. Mitigation may be completely effective, in which case the effects are eliminated, or more often, only partially effective in which case there will be residual effects.

PoEs were developed as a tool for habitat managers and proponents (as well as other practitioners) to evaluate development proposals for their effects on fish and fish habitat. In that context the activity is identified and the suite of PoEs that arise through its application must be considered. In the present context, the stressor is pre-determined (increased sediment load) and the science advice is focused on evaluating the strength of the cause-effect relationship and in providing mechanisms which lead to effects on the glass sponges. *This is a subtle but important difference in application and if the PoE framework is to be applied then it would be worthwhile to explain this in the Introduction and to reorganize the work somewhat to specifically address PoEs. In its present form, the working paper does not explicitly undertake a PoE evaluation although many of the elements can be found in the document.*

- The authors acknowledged this point.

DFO has developed a PoE for dredging that is "The physical removal of materials including rocks, bottom sediments, plants, debris, sand, and refuse from the bed of a water body/watercourse for the purpose of excavating, cleaning, deepening, widening, or lengthening the watercourse. This requires the use of a dredge machine working from the bank, in the water or floating on water." Although the activity is different, the stressors are similar to those created by the fishing activities noted in the working paper and specifically include "Resuspension and Entrainment of Sediment". The PoE diagram is illustrated below.

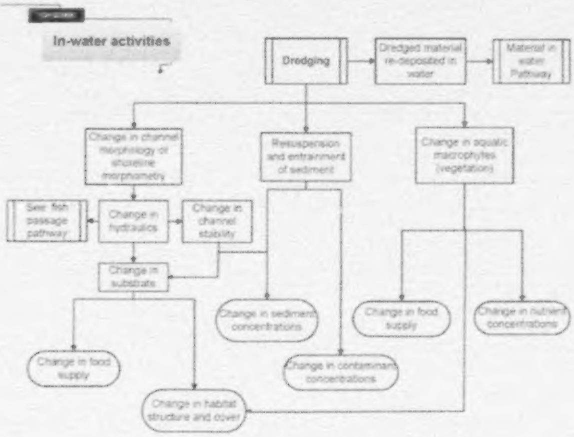

Figure 1: Pathway of Effects diagram established by DFO by expert consultation for evaluation of dredging activities.

The Reviewer suggested that the Pathways of Effects diagram could be useful to consider fishing effects on sponge reefs, as each of the listed effects could be a consequence of fishing activities. Expert consultation described the two effects arising from Resuspension and Entrainment of Sediment as:

- **Change in sediment concentrations:** Increased erosion of stream bank soils and rocks result in an excess of fragmented organic and inorganic material which is transported by water, wind, ice, and gravity. These sediments, which contain nutrifying elements and can capture or absorb contaminants, are suspended or else settle and collect in waterways affecting physical processes, structural attributes, and ecological conditions such as water clarity (by reducing visibility and sunlight and damaging fish gills) and reducing the availability and quality of spawning/ rearing habitat (through infilling).
- **Change in contaminant concentrations:** An increase in concentrations of toxins and pollutants in sediments and waters can breach the range of chemical parameters that support healthy aquatic communities, seriously affecting fish and fish habitat. The ecological effects can range from direct fatality to organisms, alteration of the ecosystem structure through changes in the abundance, composition, and diversity of communities and habitats, and persistence and progressive accumulation in sediments or biological tissues (bioaccumulation, biomagnification). Deformities, alterations in growth, reproductive success, and competitive abilities can result.

The working paper deals only with Changes in Sediment Concentrations and there should be some mention of whether a Change in Contaminant Concentrations is an issue regardless of jurisdictional issues surrounding that effect. The mobilization of sediment by towed demersal fishing gears has been related to the release of nutrients, and the resuspension of phytoplankton cysts and copepod eggs (e.g., O'Neill and Summerbell 2011) and so other effects may be appropriate to consider for this application. *Those should at least be summarized in the working paper even if the focus is on one of the pathways.*

With reference to the three elements defined by the PoE process and referred to above, Sections 3.2 and 3.3.1 of the working paper address the *list* of the fishing activities involved. This appears to be a complete evaluation and each activity is described in terms of spatial and temporal effort using a number of metrics to describe the activities. *However, only fishing activities are discussed and if the intention is to list all activities within the AMZ which could*

cause increased sedimentation, as indicated in Objective 2 of the ToR for the meeting, then the working paper or the SAR should identify any other activities that might be relevant or else state that fishing activities are the only activities that produce the effect in the prescribed area.

- The authors acknowledged that this paper was explicitly focused on the Adaptive Management Zone around the Sponge Reefs where fishing activity is the main factor hence the restricted scope. Further it was pointed out that the kinds of AMZ restrictions/actions considered in this paper are not exclusive to fisheries. They could apply to pipeline laying etc. but because the main use is fishery related, that is what is being assessed in this first step.

The effect of the fishing activities has been predetermined as an alteration of the sedimentation load in the water column which is consistent with the PoE for dredging. The authors appropriately refer to previous DFO science advice which states that all of the gear types identified through the fishing activities have some kind of impact on benthic populations, communities, and habitats. The SARs for those meetings both specify that the impacts will be context dependent and that required elements for an evaluation of the effects include:

- the specific features of the seafloor habitats, including the natural disturbance regime;
- the type of gear used, the methods and timing of deployment of the gear, and the frequency with which a site is impacted by specific gears; and
- the history of human activities, especially past fishing, in the area of concern.

The working paper addresses all of these bullets, except for a discussion of the natural disturbance regime. *This is an important point to discuss as the sediment load created through the fishing activities must be placed into context. Seasonal sediment loads are particularly important to consider in coastal areas where river outflows can cause high levels of sedimentation in the spring, associated with ice melt.*

- The authors explained that river sediment out to the continental shelf is not a big factor in Hecate Strait and Queen Charlotte Sound because it tends to get trapped before getting to the shelf. As a consequence large exposed till and glacial marine areas exist and terigenous sediment input to these reef areas is not large.

Evaluation of the strength of the resuspension of sediment pathway requires knowledge of the gear type, as well as the hydrodynamic drag of the gear, the type of sediment worked and the physical oceanography of the area. Determination of drag should be explored further in the working paper. The authors acknowledge that it is an important element but do not appear to use the information. *Therefore there is no estimate of the volume of sediment resuspended. This seems to be an important consideration and if it is possible to estimate this then it should be added to the paper (see discussion of model below).*

- The authors acknowledge that volume was not considered and suggests that this might be important to identify in the paper as lacking from the models. It could also be identified as a knowledge gap for future consideration.

There is a large body of literature on this subject but the working paper cites only one reference and does not place the gear used in the AMZ into context with that report or the broader literature. Specifically, the types of fishing gear used should be elaborated upon further to include the name of the trawl nets and doors and whether rollers, rock hopper or other devices are used. For the mobile gears, tow speed should be included in the report as it is intimately associated with hydrodynamic drag of the net. Trawl warps also contribute to drag and their lengths should be reported. *All of this should be incorporated into an estimate of drag for each of the gear types.*

- The authors explain that all variables available were considered in the model but that the model was developed based on best available knowledge at this time rather than putting effort towards design and implementation of new studies on one of the many variables.

The working paper does an excellent job of describing the specific features of the seafloor surficial geology relevant to the stressor and at appropriate spatial scales to address the issue. It might be useful to create a map that shows average grain size in addition to the surficial geology, particularly as this is used to determine settlement rates in Section 3.3.2.2. This last section is very thorough. In particular recognition of the cohesiveness of the particles and the difference that makes to their settlement is very interesting and novel to consideration of this PoE in Canada as far as I am aware.

Lastly in terms of the required elements for a PoE, there are a number of potential mechanisms through which the glass sponges may be impacted (although smothering is perhaps the most direct impact). The working paper by Dr. Leys addresses this last element.

Objective II: Soundness of the ocean current modeling and results describing the potential distribution of suspended sediments

The presentation of the ocean current modeling is an exciting aspect of this paper and it deserves more attention in the working paper given that this approach is likely to be considered by other regions in addressing similar issues. *Is there a seasonal component to the model?* The tidal cycles are clearly an important element. In the models that I am familiar with the drift trajectories are computed using circulation derived from the tides, the seasonal mean circulation, wind-driven circulation, and a surface-wind drift. The technique for computing the wind-driven circulation and for combining all the circulation components is described in Hannah et al. (2000). Given the wide application of that approach on the east coast it would be good to compare the models, at least superficially in order to facilitate future work. I am not a physical oceanographer and so am not able to evaluate the soundness of the modeling beyond drawing the comparisons with models that I am familiar with. In applying the Hannah et al. models I do find strong seasonal differences in dispersal trajectories. If there is potential for seasonal differences then there should be a discussion of what direction those impacts might take, if known. If seasonality is not an issue it should be mentioned in the working paper.

- The authors confirmed that a seasonal component was included in the model, but that perhaps more explanation was needed in the document to make this clear.

Objective III: Effectiveness of suggested mitigation measures to address the identified effects

The models are used to predict the dispersion of the resuspended sediments and this is effectively translated into potential mitigation measures. However, there is no evaluation of the amount of sediment that would be transported. This is not an issue with the soundness of the model but a larger one of the evaluation of the PoE. It will be important to complete the evaluation of drag in relation to the sediment types to estimate transport volumes before evaluating the mitigation measures. It is also important to place the modeled results into context with natural sediment loads which are likely highly seasonal related to river plumes. These analyses are needed in order to evaluation the effectiveness of the mitigation measure and whether there are any negative residual effects.

The proposed mitigation measures which align fishing activities with tidal regimes to minimize dispersal of resuspended material over the sponge grounds are interesting and should be considered further. Other measures such as gear adjustments are not mentioned and it may be that it is not cost effective to alter the gear for any realized positive effect of the change.

However, the models should be tested where possible to determine whether the sediment dispersals follow predicted tracks.

Hannah, C. G., J. A. Shore and J. W. Loder. 2000. The retention-drift dichotomy on Browns Bank: a model study of interannual variability. Can. J. Fish. Aquat. Sci. 57: 2506-2518.

DETAILED COMMENTS FROM THE REVIEWS OF AN ECOLOGICAL RISK ASSESSMENT FRAMEWORK FOR FISHERIES INDUCED RESUSPENDED SEDIMENT ON GLASS SPONGE REEFS

WORKING PAPER 1:

Leys. S. 2012. Effects of sediment on glass sponges (Porifera: Hexactinellida) and projected effects on glass sponge reefs. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/074. vi + 23 p.

- Working paper accepted with revisions
- Reviewer: Dr. Craig Young

Craig Young was not present at the meeting. His written review was presented by the Chair.

The key questions or points posed by the reviewer are presented in italicized text. The responses of the authors are bulleted with an arrow

GENERAL COMMENTS:

Dr. Leys has produced an admirable and detailed review of available information that is relevant to the potential problem of sedimentation on hexactinellid sponges, including detailed descriptions of feeding methods, experimental and correlative studies on sediment effects, and calculations of the potential effects of sedimentation on feeding rates and energetics. The review includes reference to virtually all relevant studies in the scientific literature. However, it is clear from the small number of studies that many aspects of sponge reef biology and ecology are inadequately studied. An important take-home message from the review is that resource managers should proceed cautiously because of a paucity of information on the community-wide effects. The small amount of work on the specific issue of interest (sediment effects) has all been done on just two species of hexactinellids that can be maintained in the laboratory at Bamfield Marine Lab. Possible effects are predicted by numerical extrapolations of organismal processes, but the assumptions of these calculations are not generally specified or justified.

SPECIFIC COMMENTS ON TERMS-OF-REFERENCE OBJECTIVES

Objective I: Completeness of information provided and summarized regarding the effects of sediment on sponge communities.

The first part of the review (sections 1&2) contains useful background material on filter feeding and sediment effects in demosponges. Although demosponges are very different from hexactinellids in many respects, they have been studied more thoroughly and provide some useful insights. *Figure 1 is a great illustration of the feeding structures in hexactinellids (not demosponges) from Leys' own work, but it should probably be relocated to the hexactinellid section to avoid confusion.*

- Author acknowledged and the figure will be moved.

The most important part of the discussion on demosponges deals with prior studies of sediment effects. The first two studies cited are correlative in nature and do not provide any definitive

information on sedimentation effects. The first of these (Carballo, 2006) shows a reduction of upright sponges following seasonal sedimentation events, but other factors such as seasonal differences in wave action or temperature could also produce the same effect. Innumerable covariates might also confound the second correlative study (Bannister et al., 2012) in which sediment correlates with sponge density in a comparison between Australian reefs and inshore environments. *These studies are not very useful for addressing the problem.*

- The author noted that greater clarification could be added with regard to the fact that correlative studies are not evidence specifically.

The several experimental studies on demosponges cited subsequently are more relevant. In a number of experiments, silt was applied to sponges, followed by monitoring of survival and aspects of physiology.

The summary for section 2 states in two different places that sponges can tolerate environments with high water-column turbidity, but none of the literature cited makes this point explicitly.

- The author acknowledged that reference clarification is needed.

A single lab study tested physiological effects of different concentrations of sediment, but there are no cited observations of sponges living in high turbidity field conditions. By contrast, the conclusion that deposited sediment affects sponge physiology and survival is supported by several cited experimental studies and is more definitive.

Section 3, which deals specifically with hexactinellids, contains an excellent review of the known biology, much of which has been produced by the author and her close colleagues. *In section 3.1.1, it is stated that nearly all hexactinellids live on hard bottoms. This is not true.*

- The author acknowledged that this can be clarified.

Many deep-sea species, including the genera Pheronema, Sericolophus and Hyalonema have root-like spicules that secure them in very soft, muddy bottoms.

- The author noted that with respect to the species mentioned, they are usually attached initially and then later anchored to pebbles.

The statement, *"There are a few places where glass sponges occur in high densities, and in these instances there is a balance between high turbidity (fallout of material from the water column) and current which prevents accumulation of sediment" may be true, but no citations are given in support of it.*

- The author acknowledged that a citation can be provided to clarify this point above.

I assume the author is referring to the eastern Atlantic *Pheronema* beds discussed in the following paragraph, but these beds are in soft depositional environments and I'm not sure that a compensatory balance between current and deposition rate has been documented there.

The summary of distribution in the reef sponges of western Canada is excellent, based on the author's own work and a series of papers mapping the distributions with multibeam sonar methods. Again, however, the summary statement extends beyond the data. The author makes the point "Structure and flow are important, and can offset the otherwise negative effects of turbidity because turbidity comes with increased organic matter (food); fine silt however, is not favourable." The literature review justifies the first part of this statement (structure and flow are important) but the comments about negative effects of turbidity and especially the comment about fine silt not being favorable are not supported by any of the literature cited in the section where the statement is made.

- The author noted the statements of this section can be clarified with citation of additional references.

This appears to be a conclusion based on the author's opinion. It may well be true, but should not be used for management decisions without some firm evidence, either from the literature or from targeted research.

I found it curious that there is no mention of the unusual habit of Rhabdocalyptus dawsoni, which lives in the same areas as Aphrocallistes vastus, of accumulating large amounts of fine sediment in its outer layers of spicules. A master's thesis by Boyd (1981) at the University of Victoria describes this sediment layer, which provides strong evidence that at least some hexactinellids can deal with substantial amounts of particulate material. It might be fruitful to compare sediment tolerances between Rhadbodalyptus and "clean" hexactinellids living in the same areas.

- The author pointed out that in her opinion that study was not relevant and so was not included in her review because it was not about a reef sponge. It could be added though even though it is not actually relevant to this paper and that point would also have to be made clearly and explained. The author acknowledges that this point of the reviewers will be addressed in revisions in a brief but clear manner.

In section 3.2.1 we are told that hexactinellids have wider canal systems than demosponges, making sediment rejection by contraction less effectual. However, it seems that a broader canal would also allow sediment to pass through more readily, possibly making rejection mechanisms less important. Indeed, Figure 4 supports this conclusion by showing that larger dead material passes directly through.

- The author noted that this comment by the reviewer means there was confusion and that greater clarification and explanation of figure 4 is warranted. Figure 4 will be better explained so that it is clear how filtration works in hexactinellid sponges.

Although only peripherally relevant to this review on sponges, it may be worth mentioning that carnivory has been adopted by more than the one species of ascidian mentioned in the review. Carnivorous ascidians are found in at least two families (Octacnemidae and Sorberaceae) and there are numerous species in several genera that have adopted this lifestyle in the deep sea (see section 3.3.1).

- The author acknowledged this could be added briefly to the document.

The author makes the clear point that hexactinellids are bacterivores with high retention capacity. She guesses that the slightly lower retention by Sericolophus hawaiicus might be attributed to the methodology used. A more likely possibility is that these sponges do not have the ability to retain all particles in a strong current where water is driven through the sponge by dynamic pressure. The method used took a small instantaneous sample from a large area of excurrent water surrounded by sponge tissue, where contamination from ambient water was unlikely.

- The author wondered if this issue is of relevance to this paper but will revise to refer more clearly to passive flow and uncertainty. One participant, a sponge specialist, pointed out that all glass sponges on glass reefs and all North Pacific sponges are shaped like a cup. All water inside the cup is filtered. This differs from sponges found in regions such as Hawaii that are shaped like a saucer. Consequently when researchers sample from the side of the saucer they may not obtain purely exhalent water but also simultaneous inhalant streams which would make accurate measure of current velocity difficult.

At the beginning of section 3.2.2 there is a discussion of the filtration rates and mechanisms of filtration in hexactinellids. Velocities of the excurrent stream are reported rather than volumes filtered. This is apparent only from the units of the measurements and could be clarified. The explanation of mechanisms mentions viscous entrainment, but the Bernoulli Effect and dynamic pressure, both implicated by Vogel in his discussion of sponge feeding, are likely to be more important than viscous entrainment. The process depends on oscula being higher in the benthic boundary layer than the ostial surfaces. This is not mentioned, but height of sponges becomes a relevant issue later in the review.

- The author re-iterates that Vogel makes it clear that Viscous Entrainment is the best explanation for a tubular sponge to use ambient current to enhance food processing.

The author uses measurements made on individual sponges in the lab to estimate the total filtration of entire reefs. These extrapolations must be regarded as very rough estimates.

- The author pointed out these are not extrapolations but careful measurements made *in situ*, not from images and will clarify this in the paper.

A number of questions could be raised about the assumptions. Since the average area of oscula is included in the estimate, one apparent assumption is that maximum velocity measured in the center of the oscular stream is the same as the velocity around the edges of the osculum. The physics of flow through pipes would suggest that this is not true (though I don't know if it is true for sponges).

- The author noted that no such assumption was made. The velocity estimate was reduced to take into account the drag of the edge of the osculum.

Also, we are not given any estimate of variance around the oscular density values, or estimates of the amount of time sponges are actually filtering.

- The author acknowledged that more numbers could be added to this section but this would require a lot of explanation to describe them accurately and explain the biases much of which may not be relevant to this review. The author notes that the estimated values used in the laboratory study were conservative and she will revise this research document to better explain the rate used in the calculation. The author pointed out though that it needs to be understood that a combination of field and laboratory work is essential to gather the numerical data necessary to test hypotheses regarding flow and sediment on pumping rates in glass sponges due to their deep, highly inaccessible habitat and the cost and availability of ship time.

In my opinion, this sort of extrapolation is highly questionable and even more suspect without specification of the parameters and variances.

Objective IV: accuracy of identified effects of sediment on the sponge communities in hecate strait (particularly to hexactinodidian 'glass' sponges).

The effects of sediment on the sponges themselves all come from a series of unpublished lab experiments done at Bamfield by Leys and a colleague, Tompkins-McDonald. These are very relevant to the question at hand, but extrapolation to the sponges on the reef is somewhat tenuous.

- The author pointed out that these studies are the only studies done and also points out that the work cannot be done out on the reef. The author will provide more explanation as to why working on these sponges on reef is not possible and thus laboratory settings must be used.

The transmissometry data taken in the sponge reef habitats are very useful, but I must question the unpublished sedimentation rates (50 and 100 g per year). Surely these are rounded numbers or approximations.

- The author clarified that these are not approximations and will clarify the source of these estimates in the paper

In section 4.3.1, there is a discussion of currents and residence times of water masses. Conway et al (2005) give the same residence time estimate (6 days) as Leys cites from Whitney et al. (2005) but with a much higher current velocity of 25-50 cm/s rather than 5 cm/s as mentioned here. Both values cannot be correct, unless one is an average value and the other represents an extreme. Are the values cited correctly and with appropriate attribution?

- The author explained that this was not an error; the lower value represents estimates by Whitney et al, whereas the higher values are maximums. The author will clarify this in the document.

The author also does not explain why the residence times reported by these other authors are specifically relevant to the sediment issue. A large water mass many times larger than the reef could reside over the whole reef for many days, but if a discrete cloud of sediment were to drift over the sponge reef, residence time of the sediment over a given sponge would depend on the size of the cloud and the particle flux, which is dependent on particle concentration and current speed. I suspect that a given individual sponge would be impacted for a much shorter period of time from a single trawling event. This point is important because the 6-day residence time value is also used later in the review to extrapolate the potential effects of clogging.

The effects of trawling on water-column sediment were measured in a careful study in the Mediterranean Sea, but apparently not on the shelf off Western Canada. We don't know if the quantitative effects are similar. Differences could arise from differences in particle size distribution, fishing gear or techniques, or current regimes.

- The effect of particle size, current speed and height to which sediment would be ejected is not the topic of this paper. Perhaps this can be brought together in the SAR. The author suggested this section could be deleted from this paper and referred to in the other paper.

The last paragraph of the study computes potential effects of sediment on the amount of time that sponges could gather food. These are ballpark estimates and should not be considered definitive numbers for several reasons. First, they are based on current velocities measured several meters off the bottom. Friction on the bottom causes a logarithmic decrease in velocity in the benthic boundary layer, influenced in part by the sponges themselves. Second, the effects of sediment will depend on the sizes of the sediment clouds and the particle concentrations, neither of which is known or even specified as an assumption. The 30% food reduction computed by Dr. Leys is interesting, but regulators should not be tempted to cite this number as justification for reducing trawling activity. In my opinion, the background assumptions are insufficiently tested to justify use of the calculations in real-world situations where the livelihoods of fishermen could be impacted by an overly-cautious approach.

- There was some discussion about the relevance and importance of the above estimate provided in the paper. The author pointed out she was asked to give estimates and agrees to keep the estimation but to rephrase and put forward other references.

In summary, Dr. Leys has provided a comprehensive review of the factors relevant to sediment effects, and she has done the best job possible with existing information. Her literature review is very thorough. However, there are insufficient data on direct effects of sediment on hexactinellids. Targeted field experiments on sediment effects as well as field studies of

sediment concentrations generated by trawling activities would be highly desirable before the sizes of buffer areas around the reefs are specified.

GENERAL DISCUSSION

The Chair opened the floor for comments and discussion by all RPR participants. The following represents the nature of the discussion organized by Working Paper.

WORKING PAPER #1:

Is there filtration by sponges across currents; is there an edge effect to sediment exposure? The author indicates there are only speculative answers. Reefs generally will have edge effect and Hecate Strait reefs may rely heavily on their structure. If structure is changed due to disturbance of the reef structure it is not clear what the effect would be. Specific studies would be needed to investigate this.

It was suggested that section 4.2.3 Clogging of the Sponge Filter by Sediment could be taken out because it is shown in Boutillier et al.'s paper that sediment does not stay suspended for long so this is not relevant. The author agreed to delete this section

It was suggested that glass sponges occupy a habitat range that may be defined by oxygen limitations if they were deeper but wave action effects if they were shallower. Would it be possible to better define in the paper, the known requirements for sponge reef habitat. The author noted this was not simple because there are other variables including substrate and silica concentrations.

Also what allows a sponge reef to form and not just an individual sponge is probably important but not easy to define. However the author will include a more detailed explanation of why the sponge reefs of Hecate Strait are unique.

In terms of organization throughout the paper, one participant suggested that information in the paper should be organized throughout as information generally about sponges and the specifically about the Hecate Strait sponge reefs.

The following statement was suggested to be particularly important to put into the advice document "For reef building glass sponges, loss of 30% of the energy supplies during summer periods of peak feeding could be critical". Clarification was requested however as to the meaning of "could be critical" Does this mean critical to reproduction, survival, growth? The author suspected that reefs are perched in the right spot to be able to feed and suggests that if we changed the structure the reef it would not survive. The term critical was used here to indicate we should be alert. It was suggested that what is meant is potentially critical to their survival. These animals are constrained and live on the edge without much latitude or adverse conditions.

It was pointed out that this 30% loss of energy is mentioned in the section on feeding so it would be appropriate to explain that it is critical to avoid increased mortality. The point of clarification then would be, to say that food is a limiting factor for these animals.

With regard to the use of the word "critical" another suggestion was "risk of irreversible harm" not being able to feed adequately would result in harm to the animal. The author suggested it would be more accurate to summarize this point in terms of energetic requirements. It was suggested that the paper should explain that we are inferring that a 30% loss in feeding would detrimental.

It was also suggested that it may be important to point out that resuspended sediment would not necessarily impact the whole of a reef – perhaps just the edges or a section of it. Perhaps a further clarification of this point is warranted in the discussion of impact in terms of energy loss.

It is suggested the title and content of section 4.3.2 not mention trawl as the source – just focus on the effects because the sources – like fishing activity are dealt with in the other paper.

It was noted by a participant that glass sponges are in regions where water turbidity is 7-8mg/L, and that normal reef conditions are <10mg/L. The working paper also reports that glass sponges are sensitive to turbidity >10mg/L. These values all seem very close. The author explained in fact the threshold is very close and there is a narrow tolerance limit between ambient TSS (total suspended solids) and what the sponges can handle.

It was observed that the topic of burial was perhaps missing from the document. If a sponge could not grow fast enough to get ahead of the sedimentation rate, then it would not survive. Perhaps it would be prudent to add this point to the paper.

The author pointed out that there are two papers referenced in the document that deal with burial but that little has actually been done on this topic. Basically there are three sediment impacts: 1. Problem of the sediment going into them (effect on feeding), 2. Sediment going on them (burial), and 3. Sediment accumulating around them (interfering with larval attachment).

There is evidence that burial has happened at the Hecate Strait sponge reefs. Detection of buried sponges using hydroacoustics has confirmed this. It is not known what effect this has on larval settlement.

It was pointed out that there is a summary on smothering on page 14 of the working paper and that this could be elaborated upon and also captured in the SAR. The author agrees that this point could be elaborated upon in the working paper.

WORKING PAPER #2

It was noted that in Section 2 the description of the methods, risk of exposure is missing the context. What are the elements of the risk? The authors agreed to add and will clarify which pathway of effect are being dealt with.

With regard to a paper by O'Neill that is referred to, it would be good to include an indication of where that study was undertaken.

It would also be good to clarify the process that was taken to determine which types of fishing to consider in the AMZ. The authors agreed to clarify this.

With regard to the maps it would be useful to include on them an indication of where fishing actually occurs around the AMZ. This would be useful to add context to the extent of fishing in the region. The authors agreed to add this to the extent that it does not compromise fisher confidentiality and agreed it would help to visualize why most of the boundary is not intersected by gear. The authors also noted that this would also help later in the discussion of risk assessment.

Working Paper 2: Section 3.2 Historical Fisheries in the AMZ

A discrepancy in the number of hours presented in Table 6 and 7 and on pg10 was noted. The authors agreed to check this.

Table 2 and 6. Needs an explanation about how the columns in the table are linked and derived. The authors agreed to do this.

A question was raised about Table 2 with regard to the average tow times reported. The authors explained that these are averages and so a single anomalous tow could skew the average. They agreed to add a column to include the range of tow times as well as a description of how the data were derived.

Working Paper 2: Section 3.3 Re-suspension of sediment footprint

A question was raised about the review of catch on mid water trawl which indicated that up to 18% of tows contained benthic species that could only be caught if the gear was on the bottom. Could this be an error, mid water trawls are not supposed to touch the bottom? The authors explained that fish species were used as an indicator of depth of the net. They reviewed the species reported in 133 tows. Species associated with the bottom included hake, yellow mouth rockfish and red stripe rockfish. There was some discussion from participants associated with the fishing industry suggesting that perhaps there may be some transcription errors in the original data received by DFO from the fishery. The authors pointed out that there are other species reported as well such as Dover sole and starfish that are even more indicative of contact with the bottom, but the authors suggested that they could include a caveat to explain that it is possible there may be transcription errors. They also suggested they could include a caveat around which of the indicator species are strictly bottom species.

In addition it might be helpful to include in the SAR that in future the industry could be engaged to tighten up data interpretation.

A question was raised regarding a sentence which describes the average opening of a mid-water trawl in the AMZ. The authors explained that the description is to indicate the extent of the net, but that it can be relocated in the paragraph and an introductory sentence can be added explaining the purpose of the section. There will also be more references added to the description of mid water trawling.

A question was raised about Table 9 Prawn traps which are categorized by Pacific Fishery Management Area (PFMA). It was pointed out that some sets extend to shore. It was suggested that an explanation be added so that it is clear that the number of sets listed in that table are not really relative to the reef but rather the entire PFMA. The authors agreed to add text to make clear the size of the area and include a map for prawn fishing effort.

It was also suggested it would be useful to place the figures throughout the document where the related text exists rather than at the end if possible. The authors will try to do this or at least make sure figures are referenced throughout.

It was noted that there is no mention made of shrimp trawl, which was a fishery in the area in the past. Why was this not included? The authors acknowledged that a clearer explanation of the term "Historical" is required.

A question was asked about the average grain size of the sediment used to estimate settlement rates and how it was measured. An explanation is provided about how the in field measurements are made. It was pointed out that what is really important with respect to glass sponges is that remobilized materials from outside reefs is not the same as the material that falls down and feeds the reef. Resuspended materials may not be food.

A question was asked about what influences bottom current and what is causing sediment to disperse? The authors agreed to clarify which currents are being used in the regional oceanographic current model.

Working Paper 2: Section 3.3.3.1 Model 1

A question was asked about the use of annual mean tidal currents in the model. Are there seasonal differences in the currents and would it be more appropriate to have more than one parameter for the currents throughout the year? The authors clarified the way tidal current was used in the model and that the time frames were on the order of hours. They will make clarification of this in the research document.

Working Paper 2: Section 3.3.3.2 Model 2

The authors will add a sentence explaining that the analysis was repeated for 5% and 20% of the time to reduce the buffer zone. They chose 5% and 20% as examples.

Another comment was made that a scale bar should be added to Figure 23.

There was also a question about why a range of sediment grain sizes are not used in the model. The authors explained that it would be useful to point out in the SAR that future improvements to the model could include consideration of a range of sediment grain sizes.

Working Paper 2: Section 3.3.3.3 Model 3

Regarding the results tabulated from this model there was discussion about adding an example of the lowest 15 days as a comparison and also of adding an example of the worst days to show the comparative worst case scenario.

Working Paper 2: Section 3.3.3.4 Model 4

There was discussion regarding how to present this model since it was not completed. The authors agreed to take it out of this section and add it to the section on recommendations for future research.

Working Paper 2: Section 3.4 Risk Assessment

There was a question asked about why mid water trawl is included in the "high" (score 4) consequence level. The authors explained this is because of the instances discussed earlier in which benthic fish species were found in the catches. They will also add a reference to clarify that this ranking is the result of applying a reviewed national assessment process.

There was a question about a statement in the paper: "majority of bottom and mid-water trawl fishing takes place on the Queen Charlotte Sound Southern reef complex". Does this mean the reef itself or the AMZ or the AOI? The authors agreed to clarify this to say within the Queen Charlotte Sound AOI area to best describe where fishing is in fact taking place.

Working Paper 2: Section 4 Findings from Models and ERAF

A point was raised that if the purpose of these mitigation scenarios is to give management the tools, then they will need information on uncertainty. Where is the uncertainty recorded in the risk assessment? It was pointed out that it is captured in the ERAF. The authors agreed to remove the word "intensity" from the title of section 4.1 and clarify in the document this section is referring to the models in the paper and explain that they used the mean as estimate instead of specific data for a specific location

The authors agreed to add an introduction to the section on mitigation scenarios to better explain how they came to choose these scenarios and their purpose.

It was pointed out that it would be worth mentioning that the impacts from gear can be changed considerably with gear modification. So that describing how the gear is used rather than just what the gear looks like would be helpful too. The authors indicate this is beyond the scope of this paper but suggest it should be mentioned in the SAR as something for further investigation.

It was suggested that research like that carried out for bottom trawls by O'Neill and Summerbell (2011) could be done for BC and is still required for many gear types. This should be added to future research.

It was pointed out that Scenario 4 which is dependent on model 4 which was not completed should then be moved to future research as well.

It was pointed out that Scenario 2 which refers to fishing at historical levels may not even be possible. The oceans and ocean climate are changing. The authors suggested this should be placed in the SAR – Climate change and other considerations. In the working paper they would add an important qualifier "all things being equal, or without any other changes". This paper is intended to provide a range of possible outcomes. These are not restricting and not self-limiting. They are not the full suite of management actions. Managers will come back in future and ask for changes based on current industry or oceanic conditions at the time.

Working Paper 2: Section 4.3: Cost benefit Analysis

There was some discussion as to whether this section was appropriate in a science document. Socio-economic components should be in management documents. However it was argued that this is "input" to cost-benefit analysis not the analysis itself. It should be reworked to stay within science objectives and provide some information to managers for consideration but without drawing conclusions. The authors agreed to amend/reduce the paragraph to stay within the bounds of science and to alter the title from CBA to "Science inputs to a CBA". They will also add benefits of protecting this EBSA for the broader ecosystem.

CONCLUSIONS

The following are concluding points agreed upon by the meeting participants, grouped by those pertaining to Working Paper 1 (Effects of sediment on sponges) and those pertaining to Working Paper 2 (Extent and nature of exposure to fishery induced remobilized sediment). Within these groupings they are not listed in any particular order.

Conclusions drawn from WP 1

- Sediment can affect sponges at different stages. There may be effects on recruitment success or larval settling, reduced feeding by a behavioural process, clogging by a physical process or, smothering/burial of the reef. We do not know what the chronic effects of repeated exposure are in terms of energetics and reduced reproduction. So we do not have an adequate understanding of the full range of sediment effects on glass sponge species.
- Sponges feed by filtering the material in the water for digestible organic material.
- Increase in levels of exposure of sediment above background levels may cause arrest in flow. Exposure greater than 40min can cause clogging and reduced pumping (filtration and therefore feeding).
- If passive flow is reduced due to increased resistance through sponge body due to clogging, sponge may not meet energetic requirements which would have the potential to compromise growth and future reproductive ability.

- For glass sponge reef communities, loss of 30% of the energy supplies during summer periods of peak feeding could be critical, compromising growth and future reproductive ability.
- Sediment reduces sponge pumping rates/filtration rates which is the mechanism for feeding – based on best available science.
- Re-suspension of sediments might result in burial and the effects of burial and other consequences are not tested.

Conclusions drawn from WP 2

- Current fixed and mobile fishing activities within the AMZ which are mid-water, bottom, trap, longline – can potentially impact sponge reefs through re-suspension of sediment and as such they deserve a higher level of scrutiny and potential management action.
- Use of a Risk Assessment Framework and incorporating oceanographic and sediment data through the use of sediment and current movement models provided an appropriate method for assessing risk of exposure.
- This approach also included a range of possible mitigation scenarios that may be a useful starting point as examples for management actions that could be considered.
- Management scenarios examined focused only on changing of timing of fishing events but there may be other options (such as gear modifications or behavioural changes, incentive programs could be considered.).
- Factors that affect rate and range of exposure were identified to include: 1) type of sediment (time sediment remains in water column) (remobilization), 2) nature of gear interactions with bottom (which drives the height sediment is ejected in to the water column) (flocculation) 3) current speeds in area (determine distance and time sediment travels) (dispersion model).
- Detailed work is needed on intensity of fishing methods to fine tune the data used in the models and therefore the results.
- Modeling to restrict fishing by time and area could be further explored.
- In future, when decisions to actually select and develop a mitigation method it would be beneficial to engage the commercial fishing industry along with others.
- The model results might be improved in future by use of a range of sediment sizes instead of an average grain size of 20 micron.
- Sediment volume should be considered in future as a further element of intensity.
- Research for bottom effects is still required for many gear types. There is a lot unknown about the effect of gear.
- Pathways of effects in this review was narrowed down to one activity or stressor but it would be beneficial to mention in the SAR that scope is very specific in this case (fishing) but the work and modelling may have broader applicability.
- Future consideration may need to consider how climate change (acidification, temperature, oxygen) could influence the scenarios and the reefs.

APPENDIX 1. AGENDA

Canadian Science Advisory Secretariat
Regional Peer Review

Identification and Evaluation of Biological Effects and Impacts of Sediment to Sponge Communities in Hecate Strait

Pacific Regional Science Advisory Process

October 23-25, 2012
Pacific Biological Station
Nanaimo, British Columbia

Chairperson: Linda Nichol

Day 1 – Tuesday, October 23rd

10:00	Introductions and Agenda Review	Linda Nichol
10:10	CSAS Overview and Meeting Procedures	Linda Nichol
10:20	Review of Terms of Reference	Linda Nichol
10:30	Overview Presentation WP[1] # 2 (Boutillier et al.)	Jim Boutillier
11:30	External Review	Ellen Kenchington
12:00	**Lunch break**	
1:00	Presentation of WP #1 (Leys)	Sally Leys
1:40	External Review, Presented by chair	Craig Young
2:10	Discussion ▪ WP # 1 sediment effects on Glass sponges	Participants
2:30	**Break**	
2:50	Discussion cont'd ▪ WP # 1 sediment effects on Glass sponges ▪ WP # 2 Section 3.3 Resuspension of sediment footprint ➢ Remobilized Sediment Settlement Rates ➢ Regional Oceanographic Current Model	Participants
4:30	**Adjournment**	

Day 2 – Wednesday, October 24th

9:00	Introductions & Housekeeping	Linda Nichol
9:10	Review Day 1 progress and Day 2 agenda	Linda Nichol
9:30	Discussion (Boutillier et al WP) cont'd WP # 2 Section 3.3 Resuspension of sediment footprint • Remobilized Sediment Settlement Rates • Regional Oceanographic Current Model ➢ maximum tidal excursion and sediment transport models 1, 2 ➢ mitigation potential model 3	Participants
10:30	**Break**	
10:50	Discussion (Boutillier et al WP)	Participants

[1] WP means Working Paper

	cont'd ROM and models • Section 3.4 Risk Analysis • Section 3.5 mitigation scenarios	
12:00	**Lunch Break**	
1:00	Section 4.0 Discussion of findings from models and ERAF[2] ➢ sediment assumptions ➢ Gear assumptions	Participants
2:30	**Break**	
2:50	Discussion (Boutillier et al WP) section 4 Section 4.2 Mitigation scenario results • Mitigation scenario results • Cost-benefit analysis inputs	Participants
4:30	**Adjournment**	

Day 3 – Thursday October 25th

9:00	Introductions and Housekeeping	Linda Nichol
9:10	Review of Day 2 progress and Day 3 agenda	Linda Nichol
9:30	Outstanding items for discussion from Day 1 or 2	Participants
10:30	**Break**	
10:50	Discussion: e.g. identify conclusions and recommendations that have been made	Participants
12:00	**Lunch**	
1:00	Develop Science Advisory Report • finalize conclusions and recommendations • source of uncertainty • summary • general content	Participants
4:30	**Adjournment**	

[2] ERAF means Ecological Risk Assessment Framework

APPENDIX 2. LIST OF PARTICIPANTS

Last Name	First Name	Affiliation	Attend Day 1	Attend Day 2	Attend Day 3
DFO Participation			(A = attended)		
Ackerman	Barry	FM	A	A	A
Boutillier	Jim	Science MEAD	A	A	A
Convey	Laurie	FM, South Coast	A	A	A
Curtis	Janelle	Science	A		
Davies	Sarah	Science	A	A	A
Finney	Jessica	Science MEAD	A	A	A
Gillespie	Graham	Science MEAD	A		
Joyce	Marilyn	Science CSAP	A	A	
Ladwig	Aleria	FM	A		
Leslie	Karen	EMB Oceans	A	A	A
Major	Stephanie	EMB	A		
Nichol	Linda	Science	A	A	A
O	Miriam	Science OSD	A		
Spaven	Lisa	Science, MEAD	A	A	A
Whitney	Frank	Scientist Emeritis	A	A	
Masson	Diane	Science		A	
Perry	Ian	Science	A		
Rutherford	Kate	Science, MEAD	A	A	
Kenchington	Ellen	Science, Maritimes	A	A	A
Reid	Bruce	EMB Oceans	A		
External Participation -					
Last Name	**First name**	**Affiliation**			
Bodtker	Karin	Living Oceans Society	A	A	A
Burt	Jen	CPAWS	A	A	A
Conway	Kim	NRC	A	A	
Cook	Sarah	Benthos Contracting	A	A	
Harling	Wayne	Sports Fish Advisory Board		A	
Leys	Sally	University of Alberta	A	A	A
Reiswig	Henry	UBC/RBC Museum	A	A	A
Turris	Bruce	Fishing Industry		A	A
Wallace	Scott	David Suzuki Foundation	A	A	
Kristianson	Gerry	Sports Fishing Advisory Board	A	A	
Chalmers	Dennis	Province of BC	A	A	A
Mose	Bryan	Fishing Industry	A	A	A
Fain	Isaak	IOS		A	

Reviewers for the working papers are listed below.

Last Name	First Name	Affiliation
Kenchington	Ellen	DFO Maritimes Region, Bedford Institute of Oceanography, Dartmouth, Nova Scotia
Young	Craig	Oregon Institute of Marine Biology, University of Oregon

APPENDIX 3. TERMS OF REFERENCE

Identification and Evaluation of Biological Effects and Impacts of Sediment to Sponge Communities in Hecate Strait

Pacific Regional Science Advisory Process

October 23-25, 2012

Nanaimo, BC

Chairperson: Linda Nichol

Context

The Hecate Strait and Queen Charlotte Sound Glass Sponge Reefs have been identified as an ecologically and biologically significant area due to their global geological uniqueness (Conway et al. 1991, Conway et al. 2001 & Kruatter et al. 2001), and there is international and national recognition that cold-water corals and sponge dominated communities can serve as key structural habitat for many fish and invertebrate species (DFO 2010). This area is currently in the process of being designated as an *Oceans Act* MPA as part of the Health of the Oceans Initiative. It has been identified as an Area of Interest in consideration of an ecosystem-based management (EBM) approach for the Pacific North Coast Integrated Management Area (PNCIMA), within which the reefs are located.

The proposed MPA consists of three separate areas totalling 2410 square kilometres that include the four glass sponge reef complexes located in Hecate Strait and Queen Charlotte Sound, the water column and the surrounding waters, and the seabed and subsoil to a depth of 20 meters. The three areas are referred to as the Northern Reef, the Central Reef (containing two reef complexes), and the Southern Reef. Each of the three areas is proposed to have three internal management zones, referred to as the Core Protection Zone (CPZ), the Adaptive Management Zone (AMZ) and the Vertical Adaptive Management Zone (VAMZ).

Understanding both direct and indirect stressors from activities is important to the implementation of ecosystem-based management. Indirect effects due to resuspension of sediment from human activities may affect sponge communities, including hexactinellid 'glass' sponges (Conway et al. 2001, Whitney et al. 2005, Austin et al. 2007, Yahel et al. 2007, Tompkins-MacDonald & Leys 2008), however, the nature and extent of these effects is unclear. As some activities that resuspend sediment due to contact with the bottom may be permitted in the AMZ, DFO Ecosystem Management Branch Pacific Region has requested DFO Science Pacific Region to provide an assessment of the nature and extent of the potential effects of sedimentation on glass sponge reefs and recommend mitigation measures for activities/areas where there risks to these communities are identified.

A risk-based assessment framework, previously reviewed through CSAS, will be utilized to identify activities likely to create sedimentation in the AMZ and evaluate the nature and extent their potential risk to these sponge communities (O et. al. in prep.). This risk-based framework is a tool that assists in the identification of priorities, conservation objectives, management strategies and action plans including monitoring, research and management assessments as appropriate. This assessment will then be utilized to propose and evaluate possible mitigation measures. The value of this risk-based framework is that it allows for a transparent process for

gathering, evaluating and recording information related to the risk of harm from human activities/stressors on the glass sponge communities.

Objectives

The objective of this science advisory process is to:

(i) Identify and evaluate the biological effects and impacts of sediment on sponge communities in Hecate Strait (Working Paper 1);

(ii) To identify those activities that could occur in the adaptive management zone that could impact the sponge reefs through re-suspension of sediment (Working Paper 2), and;

(iii) To identify mitigation measures for relevant activities and impacts (Working Paper 2).

The following working papers will be reviewed to provide the basis for discussion and advice:

The effects of sediment on glass sponge reefs. Leys, S.P. CSAP Working Paper 2012/P44a.

> Paper overview: Summary of knowledge of the nature sedimentation effects on sponge communities, with a specific focus on the effects of sediment on glass sponge communities in general and Hecate Strait sponge reef communities in particular.

An Ecological Risk Assessment Framework for fisheries induced resuspended sediment impacts on Hecate Strait glass sponge reefs. Boutillier, J. CSAP Working Paper 2012/P44b.

> Paper overview: Discussion of extent of the potential impacts and a discussion of various mitigation measures that may reduce the extent of the impact. This will address what activities are likely to resuspend sediment (look at PoEs and quantify effects), and the potential extent of the impacts (question 3 from original request) considering the currents, sediment, and nature of the activity.

Considerations for the review of these working papers include:

Objective (i) - Working Paper 1:

1. Completeness of information provided and summarized regarding the effects of sediment on sponge communities.
2. Accuracy of identified effects of sediment on the sponge communities in Hecate Strait (particularly to hexactinosidian 'glass' sponges).

Objective (ii) - Working Paper 2:

1. Completeness of the PoEs evaluation.
2. Soundness of the ocean current modelling and results describing the potential distribution of suspended sediments.

Objective (iii) – Working Paper 2:

1. Effectiveness of suggested mitigation measures to address the identified effects.

Expected publications

- CSAS Proceedings
- CSAS Science Advisory Report (1)
- CSAS Research Documents (2)

Participation

- DFO Science
- DFO Oceans
- DFO Habitat
- DFO Species at Risk
- DFO Fisheries Management
- Province of BC
- Fish harvester experts
- Environmental Non-governmental Organisations experts
- Academic experts

References

Austin, W.C., Conway, K.W., Barrie, J.V. and Krautter, M. 2007. Growth and morphology of a reef-forming glass sponge, *Aphrocallistes vastus* (Hexactinellida), and implications for recovery from widespread trawl damage. Porifera Research: Biodiversity, Innovation and Sustainability. 139-145.

Conway, K.W., Krautter, M., Barrie, J.V. and Neuweiler, M. 2001. Hexactinellid sponge reefs on the Canadian continental shelf: A unique "living fossil'. Geoscience Canada. 28(20): 71-78.

Conway, K.W., Barrie, J.V., Austin, W.C., and Luternauer, J.L. 1991. Holocene sponge bioherms on the western Canadian continental shelf. Continental Shelf Research. 11(8-10): 771-790.

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Krautter, M., Conway, K., Barrie, J.V., and Neuweiler, M. 2001. Discovery of a "living dinosaur": globally unique modern Hexactinellid sponge reefs off British Columbia, Canada. Facies. 44: 265-282.

Leys, S.P., Wilson, K., Holeton, C., Reiswig, H.M., Austin, W.C., and Tunnicliffe, V. 2004. Patterns of glass sponge (Porifera, Hexactinellida) distribution in coastal waters of British Columbia, Canada. Mar Ecol Prog Ser. 283: 133-149.

O, M., Martone, R., Hannah, L., Greig, L., Boutillier, J. and Patton, S. 2012. An Ecological Risk Assessment Framework (ERAF) for Ecosystem-based Oceans Management. CSAP Research Working Paper presented May 8-10, Nanaimo, BC.

Tompkins-MacDonald, G. J. and Leys, S. P. 2008. Glass sponges arrest pumping in response to sediment: implications for the physiology of the hexactinellid conduction system. Mar Biol. 154: 973-984.

Whitney, F., Conway, K., Thomson, R., Barrie, V., Krautter, M., and Mungov, G. 2005. Oceanographic habitat of sponge reefs on the Western Canadian Continental Shelf. Continental Shelf Research. 25: 211-226.

Yahel, G., Whitney, F., Reiswig, H.M., Eerkes-Medrano, D.I., and Leys, S.P. 2007. In situ feeding and metabolism of glass sponges (Hexactinellida, Porifera) studied in a deep temperate fjord with a remotely operated submersible. Limnol. Oceanogr. 52(1): 428-440.

APPENDIX 4. WORKING PAPER SUMMARIES

Leys, S. 2012. Effects of Sediment on Glass Sponges (Porifera,Hexactinellida) and projected effects on Glass Sponge Reefs. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/074. vi + 23 p.

Sponges are dependent on the environment for flow and therefore food. They lack nerves and muscle and are unable to rapidly relocate in response to changing environments. Glass sponges are particularly immobile due to their heavy silica skeleton. They are nevertheless animals which, like other animals, have tissues and sensory systems that allow them to sense changes to their environment and attempt to avoid detrimental effects. They do this either via sensory cilia and contractions of the filtration system (in demosponges) or sensory tissues and electrical signaling to arrest the feeding current (in hexactinellids = glass sponges).

Sponges are suspension feeders: they draw water through pores in their surface tissues, into canals to chambers of choanocytes where food is captured. They extract bacteria (0.2-1μm) and picoplankton (0.2-10μm) (e.g. unicellular algae). Clearance studies show sponges preferentially take up smaller particles (0-8μm), but are selective feeders – they eat the more nutritious items, and expel inedible particles. Sediment >10-11 mg/L irritates and eventually clogs the filtration system of demosponges. Clogging triggers an expulsion behaviour which causes the incurrent canals to inflate and then contract, pushing the sediment out of the sponge; several contractions in a row (about 10-40 min each) effectively expel small amounts of sediment waste.

Smothering by sediment causes increased respiration and oxygen consumption, and reduced reproductive ability and body weight. Death occurs in 3-6 months.

Glass sponges live in deep water (>30m) and usually on raised topography with accelerated flow. Reef sponges live in turbid water (high suspended solids, 7-8 mg/L) and are efficient bacteriovores. They take up nearly 99% of bacteria and 94% of unicellular eukaryotes from the water they filter. Sediment – clay/silt – is expelled as wastes. Sediment at reefs consists of 44-58% clays, and 75% of reef sediment is less than 3 microns in size. Whereas demosponges contract to expel debris and unwanted particles, Glass sponges do not contract in response to sediment (organic or inorganic), but use electrical signals to arrest feeding if irritated. No experiments have tested long-term effects of smothering of glass sponges by sediment but continued presence of >15-35 mg/mL of sediment (grain size <25μm) causes complete and continued arrest of glass sponge pumping and filtration. Longer than 40 minutes exposure to 15-35 mg/L sediment causes clogging of sponge feeding tissues. Clogging by sediment reduces filtration in the glass reef sponge by 50-80% of normal levels.

Glass reef sponges rely on induced current to reduce the energetic cost of filtration. An estimated 2/3 of the sponge's daily food intake occurs during the maximum flood tides which occur approximately 20% of the time. Trawl activities cause temporary resuspension of sediment (40-120 mg/L) during increased ambient current flows. Reef sponges take 6 hours or longer to recover normal filtration levels, which would reduce the daily time to feed by a minimum of 6 hours. Reduced feeding during maximum ambient current would deprive the reef sponges of 2/3 of their daily food intake, compromising growth and future reproductive ability.

Boutillier, J., Masson, D., Fain, I., Conway, K., Lintern, G, O, M, Davies, S., Mahaux, P., Olsen, N., Nguyen, H., Rutherford, K. 2012. The extent and nature of exposure to fishery induced remobilized sediment on the Hecate Strait and Queen Charlotte Sound glass sponge reef. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/074. vi + 23 p.

Fishing activities currently take place within Adaptive Management Zone (AMZ) of the proposed Hecate Strait and Queen Charlotte Sound Area of Interest (AOI). DFO Science has been asked to (1) assess the nature and extent of risks associated with remobilization of sediment from fishing gear, and (2) provide managers with options to mitigate these risks.

This paper summarizes fishing activities that have occurred in the AMZ from 2007 – 2011, and outlines a framework to estimate the footprint of the remobilized sediment. This framework describes: the intensity of the various fishing activities as they relate to remobilization of sediment; the various sediment types within each reef complex; the factors that affect the resettlement rates of remobilized sediment; and the dispersion of the remobilized sediment as a result of ocean currents in the region under a variety of fishing activity scenarios.

For the purposes of this paper, the potential footprint of remobilized sediment is determined for theoretical interaction of bottom trawl gear with sediment that has an average grain size and composition of: 55% silt (3.9 to 63um), 30% clay (0 to 3.9um) and 15% sand (63um+).with a calculated D50 = 20um. Two models were used to calculate the area of impact: a model which calculated the resettlement rates for the average settlement size and a dispersion model which used the resettlement rates within a regional oceanographic current model to estimate the area that would be covered. Three variations of the dispersion models were calculated for the area. The first model calculated the maximum sediment transport around the AOI. The second model calculated the potential area of impact based on historic bottom-trawl fishing boundaries. The third model calculated the potential area of impact if fishing were restricted to those days with the lowest tide cycles.

The findings of the sediment dispersion models were then used to inform the risk of exposure of the sponge reef to remobilized sediment under 6 mitigation scenarios. In addition, the information needs from biological and ecological science perspective were outlined for a cost-benefit analysis that could be used to evaluate the social and economic consequences of the various mitigation measures.